Report as of FY2011 for 2010WI253G: "Implications of Climate Change and Biofuel Development for Great Lakes Regional Water Quality and Quantity"

Publications

Project 2010WI253G has resulted in no reported publications as of FY2011.

Report Follows

Annual Progress Report

Selected Reporting Period: 3/1/2011 - 2/29/2012

Submitted By: Anita Thompson
Submitted: 5/21/2012

Project Title

WR10R008: Implications of Climate Change and Biofuel Development for Great Lakes Regional Water Quality and Quantity

Project Investigators

Anita Thompson, University of Wisconsin-Madison

Progress Statement

Objective 1 - Data Collection and Compilation

Field Data Collection: During Summer and Fall 2011, three additional Equilibrium Tension Lysimeters (ETLs) were installed in the following treatments: hybrid poplar plots (2; within plot duplication) and rotational corn (1). We now have 11 ETLs installed and working. The additional ETL in the rotational corn treatment replicates the ETL previously installed in rotational corn although the two are staggered by one year of rotation. Volumetric soil moisture reflectometers and soil temperature probes were installed at each lysimeter location. Data logger programs for controlling the operation of the ETLs were written and debugged and equipment troubleshooting continued through fall 2011. Lysimeter water samples were collected weekly starting January 1, 2011. Leachate volumes were measured starting January 1, 2011 and leachate samples collected after May 1, 2011 have been analyzed for Nitrate + Nitrite, Ammonia, Total Nitrogen, Total Phosphorus, Dissolved Reactive Phosphorus, pH, EC, and volume. Soil moisture release curves and saturated hydraulic conductivity have been measured for approximately 20 soil cores extracted from a range of depths within the plots. These measurements will be used for the modeling component of the study. Small scale (1m X 1m) surface runoff collection systems were installed during May 2011 in the following treatments: continuous corn (3 replicates), monoculture switch grass (3 replicates), and monoculture Miscanthus (3 replicates). Runoff sample collection started June 1, 2011 and samples were analyzed for Total Nitrogen, Total Phosphorus, Total Dissolved Phosphorus, Dissolved Organic Carbon, Total Sediment, Total Carbon, pH, EC, and volume. All water quality analyses were conducted in the Water Quality Laboratory in the Agricultural Engineering Laboratory Building (Biological Systems Engineering). All sample collection will continue through September, 2013.

GIS Data Collection: We are assembling GIS databases in preparation for building ILHM simulations for Trout River, Black Earth Creek, and Muskegon River watersheds. These include surficial hydrology, subsurface sediment characteristics, basic basemap layers, digital elevation models, SSURGO soil textures, remotely sensed leaf area index (LAI). We have also collected some climate data to drive the models, including NEXRAD hourly precipitation estimates, climate change forecasts (see below), and historical climate reanalyses (also see below). On site weather stations at the Arlington site have been recording local precipitation, temperature, humidity, and solar radiation for more than two years.

Objective 2 - Model Coupling and Development
SALUS Model Development: Construction of Arlington-specific SALUS models has begun, and will be ready in Summer of 2012.

ILHM Model Development: Prior to the start of this project, the research team had an ILHM simulation of the Muskegon River Watershed. We have continued to improve this during the last year, and have incorporated enhancements including: substantial improvement of SSURGO soil hydraulic properties mapping, improved precipitation data inputs, and improved wetlands simulations. These improvements are incorporated in Kendall and Hyndman (in Preparation). Simulations of the Black Earth Creek and Trout River watersheds will be constructed beginning in Fall of 2012.

SALUS-ILHM Coupling: Coupling of SALUS (Systems Approach to Land Use Sustainability) and ILHM (Integrated Landscape Hydrology Model) is following a two-phase approach: 1) initially use SALUS for a representative set of land surface characteristics to derive LAI and root growth values that are input to ILHM (a feed-forward approach), and 2) rewrite the SALUS code from its native Visual Basic to ILHM's language, MATLAB, in a fully-coupled feedback manner. Separating the coupling into two phases was selected in order to provide robust model results more quickly, while the more time-intensive full coupling moves toward completion. Progress on stage 2, the full rewrite coupling, has been steady and is anticipated to be completed during the

summer of 2012, with validation and debugging continuing through the Fall of 2012. Stage 1 coupling is also expected to be complete in summer 2012.

Climate Projection Development: During the past year we improved our methods of developing climate forecasts. Improvements include creating continuous daily climate scenarios from 1870-2100 using the 20th Century Version 2 Reanalysis and the 24 models within the CMIP-3 database used by the IPCC AR4. Along with creating continuous scenarios, this gives us the capability to rapidly assess the bias of individual CMIP-3 models relative to the 20thCv2 reanalysis.

Biofuels Land Use Scenario Development: Work done on a related project is yielding insights into a range of adaptive management strategies that may be employed by biofuels agricultural production systems in response to climate changes during the 21st century. These finding will be used along with the originally envisioned regional biofuels production scenarios later in this project.

Objective 3 - Model Validation
Stream Discharge Monitoring: In July of 2011, 3 pressure and temperature transducers were installed in streams in the Yahara River. These are being monitored and downloaded regularly, which stream discharge measurements are collected at regular intervals in order to construct a stage-discharge relationship for each stream gauge station. These will eventually yield over 2 years of detailed stream flow estimates for this watershed.

Groundwater Level Monitoring: In July of 2011, 5 pressure and temperature transducers were installed in wells nearby the Arlington site. The wells are located near a watershed divide

Stream Nutrient Data Collection: Collection of ~100 stream discharge and nutrient samples is anticipated to take place in the Summer of 2012.

Objective 4 - Model Intercomparison
Comparison of SALUS-ILHM and GSFLOW models for the three watersheds is anticipated to begin in Winter of 2012.

Additional
Two project meetings were held during which the P.I.s from the collaborating institutions (University of Wisconsin – Madison, Ball State University, Michigan State University, and the U.S. Geological Survey) discussed project planning, data requirements for the hydrologic models, preliminary field results and data collection, formatting and distribution.

Principal Findings and Significance

Principal Findings and Significance

Description

Significance
The significance of efforts during the past reporting year include: 1) all field equipment required to successfully complete our project was installed, 2) two graduate students were trained in the analytical methods for the required water quality analyses, and 3) one graduate student was trained in the installation and operation of surface monitoring equipment.

Findings
Regional Hydrologic Assessment: Water quantity and quality modeling are currently being performed on watersheds characterized by different hydrological regimes. Differences in the intrinsic physical properties of the study sites imply different groundwater storage and outflow patterns within the watersheds. For instance, the Trout watershed, a groundwater-dominated system has experienced a steady decrease in their annual Q95 streamflow (the natural river flow that is exceeded 95% of the time) values since the mid 80's, with potential impacts on the stream ecology as well as for water management purposes. Such behavior contrasts at the Black Earth watershed, where Q95 values have followed the opposite behavior, even within a longer term perspective. In turn, the concentration and fate of nutrient and pollutants during the driest period of the year may strongly differ according to the observed regime of each watershed.

Furthermore, in order to separate the effects from changes in land use to climate variability and anomaly events (eg. Pacifical Decadal Oscillation, ENSO) that affect the hydrological regime in the Great Lakes region, a set of seven natural watersheds (unaffected by artificial diversions, storage, or other works of man in or on the natural stream channels or in the watershed) located in Michigan and Wisconsin were selected from the Hydro-Climatic Data Network. The beginning of the observations in those watersheds ranges from 1899 to 1967). Additionally, groundwater recharge using the ILHM-SALUS models will be validated with the support of the Active Groundwater Level Network composed of 53 continuous wells in Wisconsin and Michigan. Currently, the data is being pre-processed and converted to the model input format

Soils and Agricultural Water Use: More than any other land use type, agricultural uses were highly sensitive to soil textural variability in a simulation study of the Muskegon River Watershed [Kendall and Hyndman, in Prep.]. Agricultural land uses in finer textured soils allowed less groundwater recharge and had higher evapotranspiration than forest or grassland types, while the reverse was true in coarse sandy textured areas. This finding highlights the need to explicitly simulate plant growth

in response to variable soil conditions, and not to rely on fixed functional behavior as is typically done with land surface modeling.

Journal Articles & Other Publications

Publication Type	Journal Article/Book Chapter (Peer-Reviewed)
Title	Simulating Spatial and Temporal Variability of Regional Evapotranspiration and Groundwater Recharge: Influences of Land Use, Soils, and Lake-Effect Climate
Author(s)	Kendall and Hyndman
Publication/Publisher	Advances in Water Resources
Year Published	
Volume & Number	
Number of Pages	
Description	In Preparation
Any Additional Citation Information	

Other Project Support

Source	USDA-NIFA Hatch
Dollar Value	$270,983
Description	Linking Cropping System Diversity with Nutrient Loss Dynamics in Alternative Biofuel Production Systems
Start Date	10/1/2009
End Date	9/30/2013

Source	Wisconsin Groundwater Coordinating Council/UW Water Resources Institute
Dollar Value	$104,695
Description	Groundwater Recharge Characteristics and Subsurface Nutrient Dynamics Under Alternate Biofuel Cropping Systems in Wisconsin
Start Date	7/1/2010
End Date	6/30/2012

Students & Post-Docs Supported

Student Name	Anthony Kendall
Campus	Other
Advisor Name	David Hyndman
Advisor Campus	Other
Degree	Post Doc
Graduation Month	
Graduation Year	
Department	Geological Sciences
Program	
Thesis Title	
Thesis Abstract	

Student Name	Damodhar Mailapalli
Campus	University of Wisconsin-Madison
Advisor Name	Anita Thompson
Advisor Campus	University of Wisconsin-Madison
Degree	Post Doc
Graduation Month	
Graduation Year	
Department	Biological Systems Engineering
Program	
Thesis Title	
Thesis Abstract	

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Student Name	Michael Polich
Campus	University of Wisconsin-Madison
Advisor Name	Anita Thompson
Advisor Campus	University of Wisconsin-Madison
Degree	Expected Masters
Graduation Month	
Graduation Year	
Department	Biological Systems Engineering
Program	
Thesis Title	
Thesis Abstract	

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Student Name	Ryan Stenjem
Campus	University of Wisconsin-Madison
Advisor Name	Anita Thompson
Advisor Campus	University of Wisconsin-Madison
Degree	Expected Masters
Graduation Month	
Graduation Year	
Department	Biological Systems Engineering
Program	Biological Systems Engineering
Thesis Title	
Thesis Abstract	

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Student Name	Zach Zopp
Campus	University of Wisconsin-Madison
Advisor Name	Anita Thompson
Advisor Campus	University of Wisconsin-Madison

Degree	Other
Graduation Month	
Graduation Year	
Department	Biological Systems Engineering
Program	
Thesis Title	
Thesis Abstract	

Undergraduate Students Supported

New Students: **4**
Continuing Students: **1**